

证明

CERTIFICATE

02110-35 P

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国际申请号: PCT/CN02/00779

INTERNATIONAL APPLICATION NUMBER

国际申请日: 04 NOV 2002 (04.11.02)

INTERNATIONAL FILING DATE

发明名称: System and Method for Hard Disc Drive Magnetic

TITLE OF INVENTION Head Flying Height Tester Calibration

申请人: SAE MAGNETICS (H. K.) LTD.

APPLICANT

中华人民共和国国家知识产权局局长

COMMISSIONER OF THE STATE INTELLECTUAL PROPERTY

OFFICE OF THE PEOPLE'S REPUBLIC OF CHINA

王景川

二零零二年十二月三十日

DECEMBER. 30. 2002

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No. PCT/CN02/00779
International Filing Date 04. NOV 2002 (04.11.02)
RO/CN 中华人民共和国国家知识产权局 PCT International Application
Name of receiving Office and "PCT International Application"
Applicant's or agent's file reference (if desired) (12 characters maximum) FPEL02150035

Box No. I TITLE OF INVENTION System and Method for Hard Disc Drive Magnetic Head Flying Height Tester Calibration	
Box No. II APPLICANT <input type="checkbox"/> This person is also inventor	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) SAE MAGNETICS (H. K.) LTD. SAE Tower, 38-42 Kwai Fung Crescent Kwai Chung N. T. Hong Kong Special Administrative Region, P. R. of China	Telephone No. Facsimile No. Teleprinter No. Applicant's registration No. with the Office
State (that is, country) of nationality: CN	State (that is, country) of residence: CN
This person is applicant for the purposes of: <input checked="" type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
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Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.) YU, Li Winnerway Industrial Area, Nancheng, Dongguan City Guangdong Province, P. R. of China Zip Code: 511700	This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input checked="" type="checkbox"/> inventor only (If this check-box is marked, do not fill in below.) Applicant's registration No. with the Office
State (that is, country) of nationality:	State (that is, country) of residence:
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
<input checked="" type="checkbox"/> Further applicants and or (further) inventors are indicated on a continuation sheet.	
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Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.) China Patent Agent (H.K.) Ltd. CHINA PATENT AGENT (H.K.) LTD. 22/F, Great Eagle Centre 23 Harbour Road, Wanchai Hong Kong Special Administrative Region The People's Republic of China	Telephone No. (852)28284688 Facsimile No. (852)28271018 Teleprinter No. Agent's registration No. with the Office
<input type="checkbox"/> Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.	

Sheet No. ... 2 ...

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

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HU, Yuanzhan
Winnerway Industrial Area,
Nancheng, Dongguan City
Guangdong Province,
P. R. of China Zip Code: 511700

This person is:

- ☐ applicant only
☐ applicant and inventor
☒ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

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This person is applicant for the purposes of:

- ☐ all designated States ☐ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

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This person is:

- ☐ applicant only
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State (that is, country) of nationality:

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Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

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This person is:

- ☐ applicant only
☐ applicant and inventor
☐ inventor only (If this check-box is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

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The following designations are hereby made under Rule 4.9(a):

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| <input type="checkbox"/> DM Dominica | <input type="checkbox"/> MG Madagascar | <input type="checkbox"/> US United States of America |
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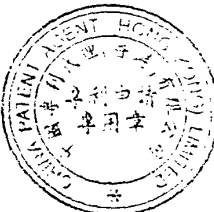
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Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

Sheet No.4....

Box No. VI PRIORITY CLAIM				
The priority of the following earlier application(s) is hereby claimed:				
Filing date of earlier application (day-month-year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				
item (4)				
item (5)				
<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box.				
The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) <i>(only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office)</i> identified above as:				
<input type="checkbox"/> all items <input type="checkbox"/> item (1) <input type="checkbox"/> item (2) <input type="checkbox"/> item (3) <input type="checkbox"/> item (4) <input type="checkbox"/> item (5) <input type="checkbox"/> other, see Supplemental Box				
* Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):				
Box No. VII INTERNATIONAL SEARCHING AUTHORITY				
Choice of International Searching Authority (ISA) <i>(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):</i>				
ISA :				
Request to use results of earlier search: reference to that search <i>(if an earlier search has been carried out by or requested from the International Searching Authority):</i>				
Date (day/month/year)	Number	Country (or regional Office)		
Box No. VIII DECLARATIONS				
The following declarations are contained in Boxes Nos. VIII (i) to (v) <i>(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):</i>				Number of declarations
<input type="checkbox"/> Box No. VIII (i)	Declaration as to the identity of the inventor			:
<input type="checkbox"/> Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent			:
<input type="checkbox"/> Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application			:
<input type="checkbox"/> Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America)			:
<input type="checkbox"/> Box No. VIII (v)	Déclaration as to non-prejudicial disclosures or exceptions to lack of novelty			:

Sheet No. 5

Box No. IX CHECK LIST: LANGUAGE OF FILING		
This international application contains: (a) the following number of sheets in paper form: request (including declaration sheets) : 5 description (excluding sequence listing part) : 10 claims : 5 abstract : 1 drawings : 6 Sub-total number of sheets : 27 sequence listing part of description (actual number of sheets if filed in paper form, whether or not also filed in computer readable form, see (b) below) : Total number of sheets : 27 (b) sequence listing part of description filed in computer readable form (i) <input type="checkbox"/> only (under Section 801(a)(i)) (ii) <input type="checkbox"/> in addition to being filed in paper form (under Section 801(a)(ii)) Type and number of carriers (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained (additional copies to be indicated under item 9(iii), in right column):		This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item): 1. <input checked="" type="checkbox"/> fee calculation sheet : 1 2. <input checked="" type="checkbox"/> original separate power of attorney : 1 3. <input type="checkbox"/> original general power of attorney : 4. <input type="checkbox"/> copy of general power of attorney; reference number, if any: : 5. <input type="checkbox"/> statement explaining lack of signature : 6. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s): : 7. <input type="checkbox"/> translation of international application into (language): : 8. <input type="checkbox"/> separate indications concerning deposited microorganism or other biological material : 9. <input type="checkbox"/> sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other)) : (i) <input type="checkbox"/> copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application) : (ii) <input type="checkbox"/> (only where check-box (b)(i) or (b)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter : (iii) <input type="checkbox"/> together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column : 10. <input type="checkbox"/> other (specify): :
Figure of the drawings which should accompany the abstract: Fig 5d		Language of filing of the international application: EN
Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).		
		

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1. Date of actual receipt of the purported international application:	04 NOV 2002 (04.11.02)	2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority (if two or more are competent): ISA /	6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid	
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FEE CALCULATION SHEET

Annex to the Request

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PCT/CN02/00779

International Application No.

04 NOV 2002 (04.11.02)

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file reference

FPEL02150035

Applicant

SAE MAGNETICS (H.K.) LTD.

CALCULATION OF PRESCRIBED FEES

1 TRANSMITTAL FEE

CNY500

T

2 SEARCH FEE

CNY1500

S

International search to be carried out by CN
(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3 INTERNATIONAL FEE

Basic Fee

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[b1] first 30 sheets

CHF650

[b1]

[b2]

number of sheets
in excess of 30

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fee per sheet

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[b2]

[b3] additional component (only if sequence listing part of description
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both in that form and on paper, under Section 801(a)(ii)):

400 x

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CHF650

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The international application contains 1 designations.

1

CHF140

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CHF790

I

(Applicants from certain States are entitled to a reduction of 75% of the
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to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT (if applicable)

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5. TOTAL FEES PAYABLE

CNY2000CHF790

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TOTAL

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SYSTEM AND METHOD FOR HARD DISC DRIVE MAGNETIC HEAD FLYING
HEIGHT TESTER CALIBRATION

Background Information

5 [0001] The present invention relates to optical gap measuring tool calibration. More specifically, the invention relates to a system for calibrating a hard disc drive magnetic head flying height tester by optical interference techniques.

[0002] Figure 1 provides an illustration of a typical hard disc drive. In the art of hard disc drives, magnetic read/write heads 102 are commonly integrated in a slider 102 designed to
10 respond to a flow of air moving with the rotating disc 104 over which the slider 102 travels. The head/slider 102 'flies' close to the surface of the disc 104. In manufacturing such heads/sliders 102, it is often necessary to test hydrodynamic characteristics of the heads 102 to verify their performance. It is important that the head 102 not travel too far from or close to the disc 104 surface. Further, it is important to prevent the head 102 from traveling at an
15 improper angle with respect to the disc surface 104. A head 102 traveling too high above the disc surface 104 will result in a lower than desired areal density. A head 102 traveling too low can cause an interface failure between the head 102 and disc 104.

[0003] In order to test the flying height of the head, a flying height tester is commonly used. Optical interference techniques are employed to determine the distance between head and
20 disc. A monochromatic light source is directed at a transparent surrogate disc, such as a glass disc, rotating at speeds similar to that of a magnetic disc, and the head assembly being tested is secured in a holder in its normal flying orientation in relation to the disc. The monochromatic light is directed at the disc at a predetermined angle to the surface thereof. The light is reflected from the surface of the disc closest to the head, as well as from the
25 surface of the flying head itself, and impinges onto a light sensitive sensor.

[0004] The interference effects created by the combined reflections from the disc and the slider surface provide the flying height information. A computer receives data from the flying height tester and calculates the perceived flying height and angle of the head. As hard drives become smaller and increase in data storage capacity, the desired head flying height continually reduces. Therefore, the accuracy of a flying height tester, and thus its calibration, are of critical concern.

[0005] In the art, calibration of flying height testers has been accomplished through the use of a standard head whose characteristics are known. However, after repeated use, the reflective surface and flying characteristics of the head are altered by dust, oil and other foreign matter. These contaminants can alter the standard for calibration purposes. The calibration of flying height testers is also performed by a standard comprising a substrate having a reflective layer deposited thereon to represent the head and a transparent layer having a predetermined thickness deposited on the reflective layer. The standard is placed in the flying height tester with the transparent layer spaced from the disc and monochromatic light directed at the standard. A disadvantage of such a standard is that it uses a transparent material rather than air between the disc and the reflective layer. In addition, such a standard does not provide for the accurate determination of position along the length of the standard.

[0006] Figure 2 illustrates another flying height tester (optical gap measuring tool) calibration standard known in the art and described in US Patent Number 5,453,831 to Li et al. A wedge slider 34 is held in contact with a transparent disc 32. One end 42 of the wedge slider is raised, creating an optical wedge between the wedge slider 34 and the disc 32. The wedge slider 34 has a first rail 52 and a second rail 54, each of which extends along the length of the wedge slider 34 and has a surface 55 facing the disc 32. The first rail 52 has a plurality of cylindrical portions 56 therein at regularly spaced intervals. Each cylindrical

portion 56 has a diameter equal to the diameter of the beam spot from the light source 72 of the flying height tester, thus allowing the beam spot to be matched at the position of any given cylindrical portion 56. The second rail 54 has a width that is greater than the diameter of the beam spot, thereby allowing for a continuous optical wedge measurement along its length. The second rail 54 may also have a plurality of marks on one side, which can be used to determine the position along the length of the wedge slider at which a measurement is taken.

[0007] To calibrate the flying height tester, the distance between the wedge slider 34 and the disc 32 is measured at multiple locations along its length and compared with known, or expected, values of the flying height at those locations. The flying height is measured at multiple locations by optical interference techniques. The expected value of the flying height at each position along the length of the wedge slider is calculated using the known dimensions of the wedge slider. The calculation is corrected for any surface irregularities found during a mapping of the surface of the first and second rails.

[0008] One disadvantage of a flying height tester calibration standard such as this is the complexity of design. Manufacturing such a device at such a small scale is very difficult and expensive. Further, the likelihood of form and material irregularities increases with complexity of design. Still further, the determination of the exact lateral position of the measurement is a problem, which is only partially resolved by the incorporation of the cylindrical portions 56 in the design described in figure 2 (causing increased design complexity).

[0009] Yet another disadvantage of this design is the effect of phase change upon reflection. This difficulty is described in an article entitled "Interferometric Measurement of Disk/Slider Spacing: The Effect of Phase Shift on Reflection" by C. Lacey, T. Shelor, A.J. Cormier, and R.E. Talke. This article provides that the optical properties of slider materials can introduce

errors as large as 20 nanometers (nm) in flying height sensors. These same problems apply to calibration standards. To compensate for such potential errors, the calibration standard must itself be carefully set up for phase change on reflection, using ellipsometric techniques. For example, US Patent Number 5,453,831 recommends fabricating a separate block of the same material as that of the wedge slider calibration standard. This piece of material is assumed to have the same optical properties as the wedge slider and may be used to determine the phase change on reflection using an ellipsometer or like optical instrument. This separate step complicates the current process further, as well as introducing uncertainties into the calibration.

10 [0010] Figure 3 illustrates another calibration standard known in the art and described in US Patent Number 5,724,134 to de Groot et al. As shown in figure 3, the apparatus is comprised principally of two elements 10,20. One or both of the elements is fabricated from a substantially transparent material such as glass or the like, thus permitting access to the gap for optical inspection. One of the surfaces of the first of these elements is substantially flat or planar 15, and one of the surfaces of the second element is non-planar or curved 25. The curved surface 25 is preferably convex spherical in form. The two principle elements of the apparatus of the present invention are held together in such a way that the curved surface of the second element is substantially in contact with the flat surface of the first element. Since a curved surface and a flat surface cannot be entirely in contact over the entire area of either one of the two surfaces, the region of contact 80 is typically substantially smaller in area than either of the two surfaces. Outside the region of contact 80, the gap between the surfaces varies according to the known geometric curvature of the surface on the second element.

[0011] One problem with this design involves the measurement uncertainty within the contact area (zeroed region). Between the first element 10 and second element 20 there is a

contact area 80 of at least 3 millimeters (mm). This is due to physical deformation towards the center of the curved surface (caused by the pressing of the first element 10 to the second element 20). The broad region of contact makes it difficult to resolve accurate height information with respect to measurement location for calibration. The amount of physical deformation affects the resulting calibration data.

[0012] Figure 4 illustrates an example of the adverse effects of surface deformation occurring in a calibration standard such as is described in the '134 patent. As shown in figure 4a, with minimal pressure and slight deformation, the calibration standard provides a zeroed reading at the center of the curved surface ($z = 0$ nanometers(nm) at $x = 6$ millimeters(mm)) 402. By comparison, with greater deformation of the center surface, it is more difficult to resolve the contact location. The chart actually shows a negative height value between 4.5 and 7.5. (See reference 404). Once the first element 10 is affixed to the second element 20 (typically by adhesive), the deformation is fixed as well. With this deformation when measuring such small gaps, it is very difficult to determine where the contact point is.

[0013] It is therefore desirable to have a system for calibrating flying height testers that avoids the above-mentioned problems, as well as having additional benefits.

Brief Description Of The Drawings

[0014] Figure 1 provides an illustration of a typical hard disc drive.

[0015] Figure 2 illustrates another flying height tester (optical gap measuring tool) calibration standard known in the art.

[0016] Figure 3 illustrates another calibration standard known in the art.

[0017] Figure 4 illustrates an example of the adverse effects of surface deformation occurring in a calibration standard.

[0018] Figure 5 illustrates a flying height tester calibration standard according to an embodiment of the present invention.

[0019] Figure 6 illustrates the calibration of a flying height tester with a calibration standard according to an embodiment of the present invention.

5

Detailed Description

[0020] Figure 5 illustrates a flying height tester calibration standard according to an embodiment of the present invention. As illustrated in fig. 5d, in this embodiment, a wedge-shaped air space 55 is provided by a tilted mock slider 50, having three bumps (bracing
10 beams) 52,53,54, each made of a material such as Pattern Diamond-Like Carbon (PDLC). The bracing beams 52,53,54 are in contact with a substantially smooth, transparent mock disc 10. In one embodiment, the mock disc 10 is actually disc-shaped. The mock disc 10 may be a transparent material such as glass. In one embodiment, a suspension arm 40 is utilized to ensure the beams 52,53,54 maintain contact with the mock disc 10.

15 [0021] As illustrated in fig. 5b, in one embodiment, the mock slider 50 is rectangular 504. As illustrated in fig. 5a, in an alternative embodiment, the mock slider is triangular 502. The mock slider may be a head substrate. In one embodiment, a mock recording head (not shown) may be applied to the mock slider 50 by thin film chemical deposition.

[0022] As shown in figure 5c, in one embodiment, the heights (actual heights) of the three
20 beams 52,53,54 are different. In one embodiment, two 52,53 of the three beams have substantially the same height. Their lengths may be measured by a tool such as an Atomic Force Microscope (AFM). Knowing the actual lengths of each of the three beams 52,53,54 makes it possible to find the distance (actual height) between the mock slider 50 and mock disc 10 at any point (explained below). The mock slider 50 contacting the disc 10 via the
25 beams 52,53,54 prevents the zeroing problem (deformation) described above.

[0023] In one embodiment, a flying height tester (not shown) is calibrated by first inserting the standard 100 into the tester. The distance (measured distance) between the mock slider 50 and the mock disc 10 is measured at multiple locations along the mock slider's 50 length and compared with known or expected values of the flying height (actual distance) at those locations. The measured height (measured distance) may be measured by known optical interference techniques. As further explained below, the actual distances at each location along the length of the mock slider 50 may be calculated using the actual lengths of the beams 52,53,54. In one embodiment, this calculation may then be corrected for any surface irregularities found during a mapping of the surface of the bar/slider by a tool such as a profilometer. The acquired surface irregularity information may be used by a computer to provide a correction function or a series of correction factors.

[0024] As shown in fig. 5d, in one embodiment, the interior of the calibration standard 100 is protected from contaminants by an enclosure 70. In one embodiment, the enclosure 70 is secured to fixtures 81,82 by attaching means such as screws 91,92. In this embodiment, the fixtures 81,82 are secured to the mock disc by a material such as an adhesive. In one embodiment, the mock slider 50 contacts the mock disc 10 via the beams 52,53,54. The mock slider 50 is held to the mock disc 10 by the spring force (pre-loaded bend) of the suspension arm 40 (amount of force necessary to maintain contact).

[0025] As illustrated in fig. 5d, in one embodiment, three support bumps 42,43,44 of substantially the same height are located on the suspension arm 40. In this embodiment, each support bump 42,43,44 is located directly below a respective bracing beam 52,53,54 on the mock slider 50. In one embodiment, the suspension arm 40 has two locating pins 45,46, which are utilized to maintain the mock slider's 50 position upon the suspension arm 40. In one embodiment, the locating pins 45,46 are shorter (come to a point lower) than the surface of the mock slider 50 upon the support bumps 42,43,44.

[0026] Figure 6 illustrates the calibration of a flying height tester with a calibration standard according to an embodiment of the present invention. The difference in height of the beams 52,53,54 causes an angle 'a' between the mock slider surface 51 and the mock disc surface 12. The horizontal position along the length of the mock slider 50 is described by the variable 'y' from $y=0$ to $y=L$ (x, y, and z-axis illustrated in fig. 6c). The vertical distance (or flying height) between the mock disc surface 12 and the mock slider 50 is described by the variable 'h'. The flying height h varies with y from 'h1' at $y=0$ to 'h2' at $y=L$.

[0027] In one embodiment of the present invention, as illustrated in fig. 6a, to calibrate a flying height tester, the calibration standard 100 is placed in the flying height tester in place of the glass disc (not shown) of the tester under the tester's light source 60. In calibrating the flying height tester, height measurements are taken by the tester ('measured distance') at multiple points along the mock slider's length (y-axis). The measured distances are compared with the known (or expected) values ('actual distances') at those locations. In one embodiment, a linear translator and computer (not shown) are utilized to position the standard 100.

[0028] In this embodiment, at each measurement point, monochromatic light 68a is directed at the (transparent) mock disc 10 by the light source 60, as shown in fig. 6a. The light 68a impinges the disc 10 at an angle 2 incident to a first mock disc surface 11 and continues through the (glass) mock disc 10 along path 68b to a second mock disc surface 12, where it splits and is partially reflected. The reflected portion follows path 68c through the disc 10 to the first surface 11, and follows path 68d to a sensor of the flying height tester (not shown). The remaining light follows path 68e to the mock slider surface 51 where it is reflected to the mock disc 10 via path 68f. The light impinges the second surface 12 of the mock disc 10, follows path 68g through the disc 10 and follows path 68h to the tester sensor (not shown). The slight angular deviations between paths at the air/disc interface are due to the Snell effect.

Both the height h_1, h_2 and the incident angle 2 have been exaggerated in fig. 6a for illustrative purposes. Path 68a is actually substantially normal to the mock disc surface 11 with typical flying height testers. In one embodiment of the present invention, the height $H_d = h_2 - h_1$ is between 12 and 13 microinches and the length L is between .045 and 0.1 inches.

5 [0029] In one embodiment, utilizing the following solid geometry equation,

$$\frac{H_a - H_b}{2W} X + \frac{2H_c - H_a - H_b}{2L} Y + Z - H_c = 0, \text{ and setting } H_a = H_b = H,$$

$Z = \frac{H - H_c}{L} Y + H_c$, is yielded. Further, in this embodiment, the angle α may be developed

from $\cos \alpha = \frac{1}{\sqrt{\left(\frac{H_c - H}{L}\right)^2 + 1}}$. In one embodiment, the angle α is less than 0.01098° .

[0030] In this embodiment, the beams 52,53,54 are cylindrical, each beam having a
10 diameter of 394 microinches (10 microns) and a hemispherical tip (contacting the mock disc 10) to minimize the surface contact area. As stated above, in one embodiment, the beams are a material such as Pattern Diamond Like Carbon (PDLC) and formed by a method such as deposition or ion milling, the height being controlled by deposition/milling time.

[0031] To overcome the problem with the prior art of design/manufacturing complexity, an
15 embodiment of the present invention requires only a substantially flat, planar surface for the mock slider 50 (as compared to the complex design provided by the '831 patent). To overcome the zeroing problem of the prior art, an embodiment of the present invention avoids having contact between the mock slider 50 and the mock disc 10 (by using bracing beams 52,53,54). To overcome the difficulty of measurement location identification in the prior art,
20 in one embodiment, measurement scale markings 602 are provided on the surface of the mock slider 604 facing the mock disc (not shown), as illustrated in figures 6d and 6e.

[0032] Although several embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

What is claimed

1. A method for calibrating a gap measuring tool comprising:

providing a calibration standard including a mock disc and a mock slider with a
5 plurality of bracing beams, each of said beams having a known respective length and said
plurality of beams separating and maintaining a space between said slider and said disc;

determining an actual distance between said slider and said disc at a plurality of
locations based on the known respective lengths of the beams;

determining an observed distance between said slider and said disc at one or more of
10 said locations; and

comparing said observed distance to said actual distance at each of said locations.

2. The method of claim 1, wherein said space between said slider and said disc is a 'wedge'-
shaped space.

15

3. The method of claim 1, wherein said gap measuring tool is a hard disc drive head flying
height tester.

4. The method of claim 1, further comprising:

20 adjusting said gap measuring tool based on said comparing said observed distance to said
actual distance.

5. The method of claim 1, further comprising:

determining a differential between said observed distance and said actual distance; and

adjusting said gap measuring tool based on said differential.

6. The method of claim 1, further comprising:

5 providing a suspension arm to secure the slider to the disc and to maintain the slider's position with respect to the disc.

7. The method of claim 6, wherein said suspension arm includes a number of locating pins capable of accepting and maintaining said slider in a proper orientation with respect to said disc, said disc being pressed against said disc by said suspension arm.

10

8. The method of claim 6, wherein said slider and said suspension arm are generally enclosed within said calibration standard.

15

9. The method of claim 1, wherein said bracing beams are Pattern Diamond-Like Carbon (PDLIC).

10. The method of claim 1, wherein said mock slider is a magnetic head/slider substrate.

11. The method of claim 10, wherein said slider includes a film of overcoat.

20

12. The method of claim 1, wherein said mock disc is an optically transparent disc.

13. The method of claim 12 wherein said disc is glass.

14. The method of claim 1, wherein said determining said observed distance between said slider and said disc is performed by optical interference techniques.

15. The method of claim 14 further comprising:

5 providing one or more measurement scale markings upon a surface of said slider facing said disc, each of said markings associated to a respective actual distance from said disc.

16. The method of claim 15 wherein said comparing said observed distance to said actual distance includes comparing the actual distance associated to a scale marking to an observed
10 distance at that location.

17. A system for calibrating a gap measuring tool comprising:

a calibration standard including a mock disc and a mock slider, said mock slider including a plurality of bracing beams, wherein

15 each of said beams is of a known respective length, said respective length for determining an actual distance between said slider and said disc at a plurality of locations;

said plurality of beams is to separate and maintain a space between said slider and said disc; and

said calibration standard is for determining an observed distance between said slider
20 and said disc at one or more of said locations for a comparison between said observed distance and said actual distance at each of said locations.

18. The system of claim 17, wherein said space between said slider and said disc is a 'wedge'-shaped space.

19. The system of claim 17 wherein said gap measuring tool is a hard disc drive head flying height tester.

20. The system of claim 17, wherein said gap measuring tool is to be adjusted based on said
5 comparison between said observed distance and said actual distance.

21. The system of claim 17 wherein a differential between said observed distance and said actual distance is to be used for adjusting said gap measuring tool.

10 22. The system of claim 17 wherein a suspension arm is to secure the slider to the disc and is used to maintain the slider's position with respect to the disc.

23. The system of claim 22 wherein said suspension arm includes a number of locating pins capable of accepting and maintaining said slider in a proper orientation with respect to said
15 disc, said disc being pressed against said disc by said suspension arm.

24. The system of claim 22 wherein said slider and said suspension arm are generally enclosed within said calibration standard.

20 25. The system of claim 17 wherein said bracing beams are Pattern Diamond-Like Carbon (PDLC).

26. The system of claim 17 wherein said mock slider is a wedge slider.

27. The system of claim 26 wherein said slider includes a film of overcoat.

28. The system of claim 17 wherein said mock disc is an optically transparent disc.

5 29. The system of claim 28 wherein said disc is glass.

30. The system of claim 17 wherein said observed distance between said slider and said disc is determined by optical interference techniques.

10 31. The system of claim 30 wherein said slider has one or more measurement scale markings upon a slider surface facing said disc, each of said markings associated to a respective actual distance from said disc.

15 32. The system of claim 31 wherein said comparison between said observed distance and said actual distance includes comparing the actual distance associated to a scale marking to an observed distance at that location.

Abstract

A system and method are disclosed for calibrating a hard disc drive magnetic head flying height tester by a calibration standard, which includes a mock slider and mock disc, by optical interference techniques.

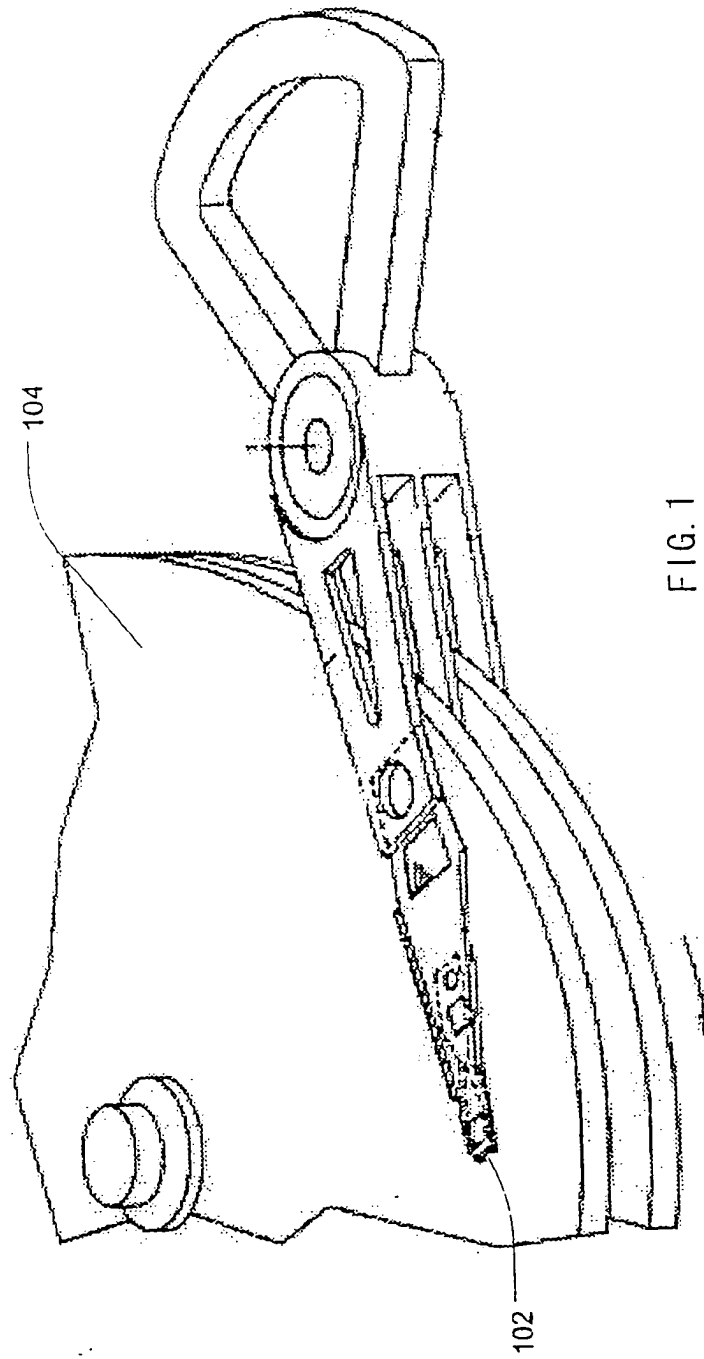


FIG. 1
Prior Art

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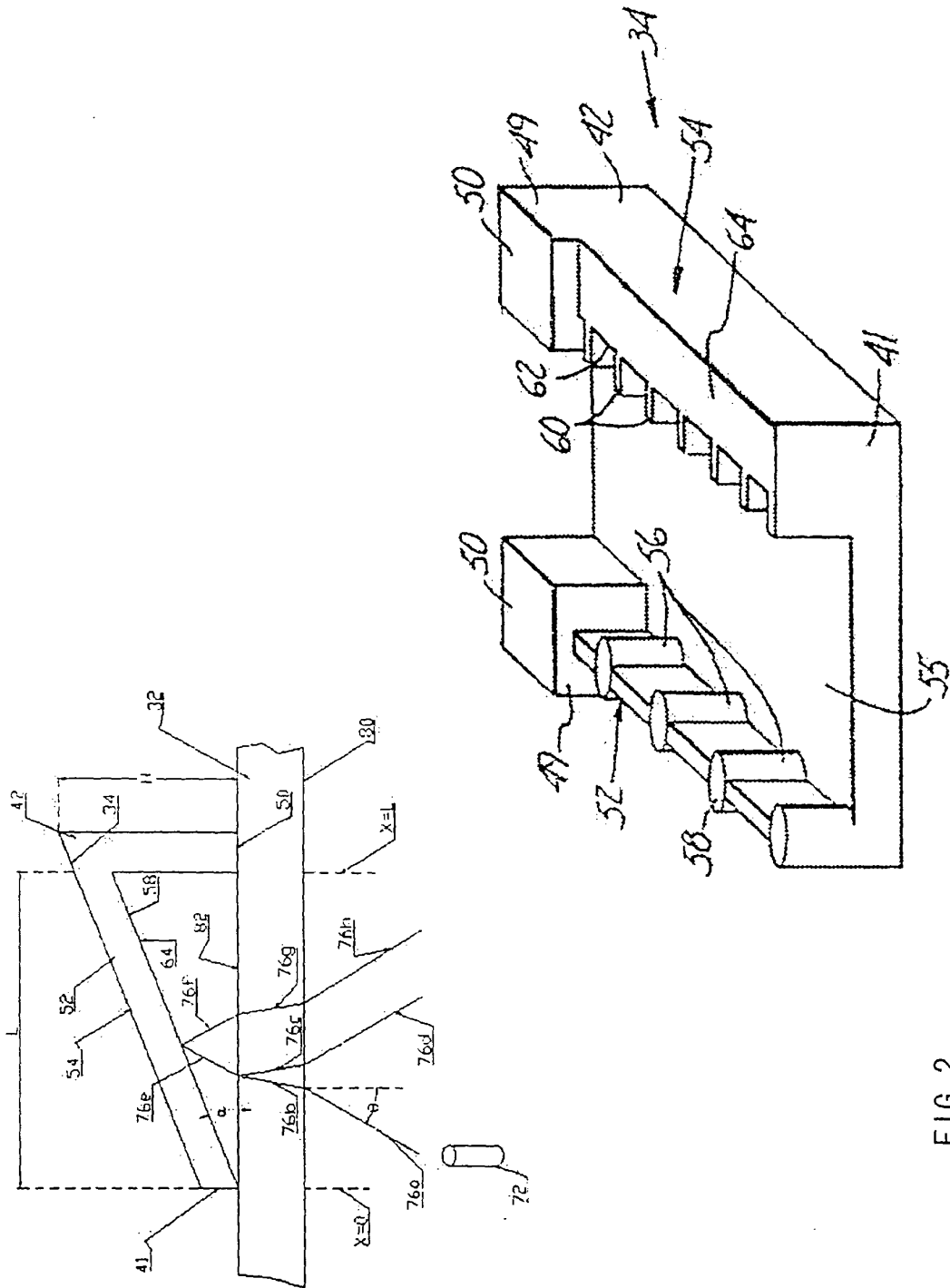


FIG. 2
Prior Art

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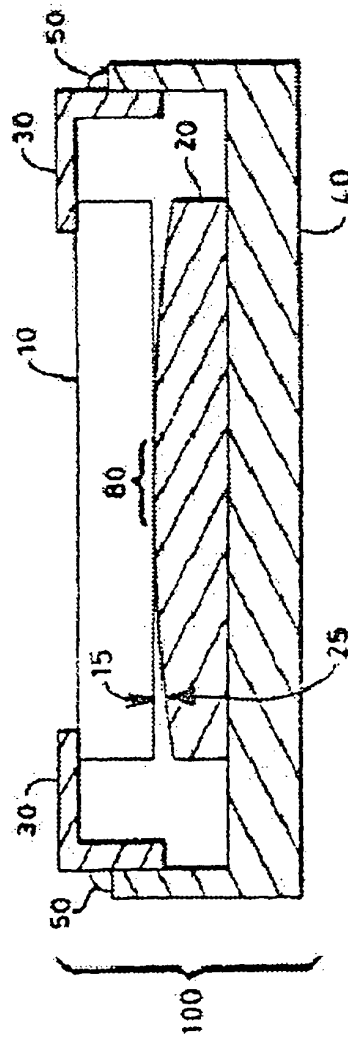


FIG. 3
Prior Art

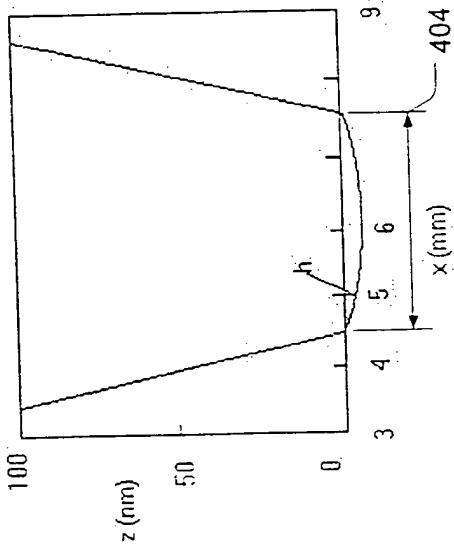


Fig.4b

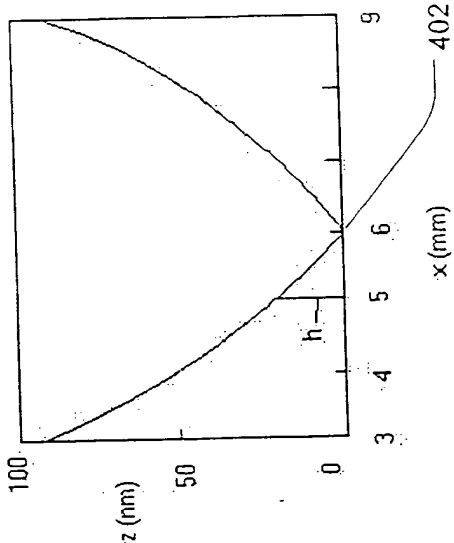


Fig.4a

FIG. 4
Prior Art

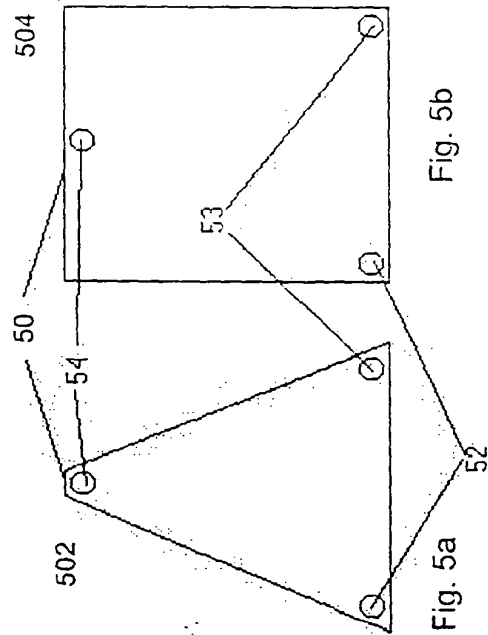


Fig. 5a

Fig. 5b

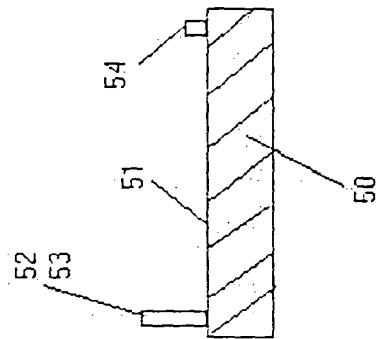


Fig. 5c

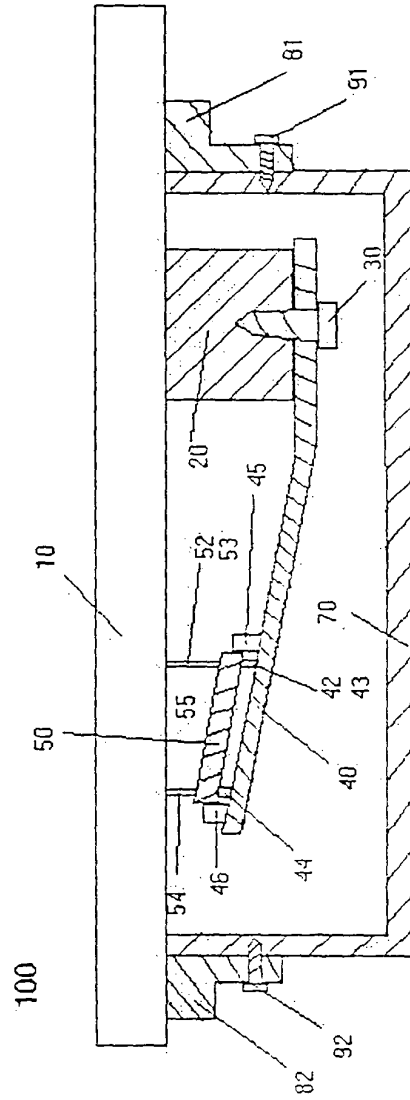


Fig. 5d

FIG. 5

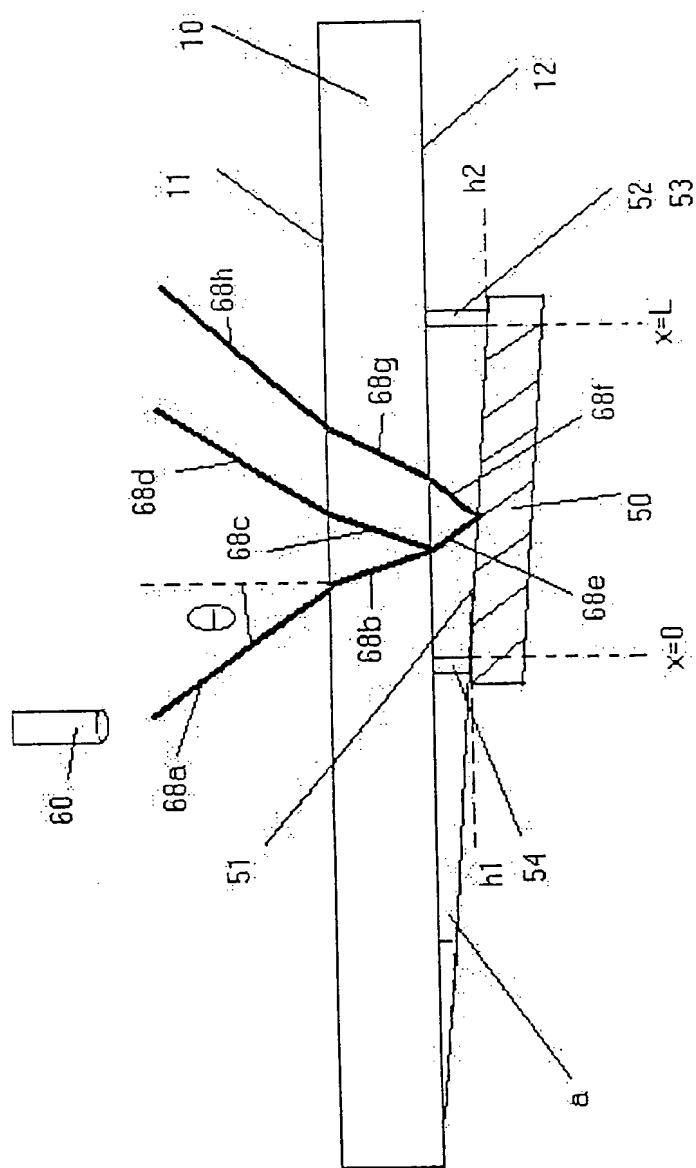


Fig. 6a

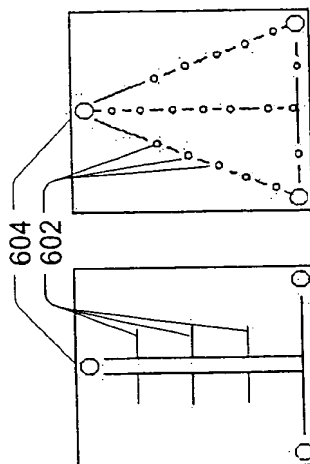


Fig. 6e

Fig. 6d

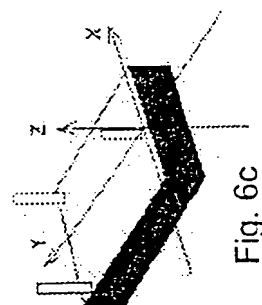


Fig. 6c

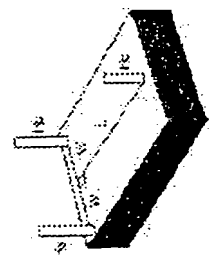


Fig. 6b

FIG. 6